

# **PROCEDURE FOR CHECKING AND RECORDING DUMMY ACCELEROMETER POLARITY FOR THE HIII 50<sup>TH</sup> AND 5<sup>TH</sup> PERCENTILE NINE ACCELEROMETER ARRAY HEAD WITH REDUNDANT C.G. ACCELEROMETERS**

## **Purpose:**

The purpose of this procedure is to provide a practical methodology for checking and documenting the recorded polarity of the data channel for each dummy mounted accelerometer relative to the NHTSA sign convention. Documenting the polarity of channels will serve to increase the confidence that polarities have been correctly determined. The polarities in this document are the same as those of the SAE J211 and J1733.

## **Background:**

Standardized coordinate systems and recorded polarities for various transducer outputs defined relative to positive directions of those coordinate systems are defined for crash test dummies, vehicle structures, and laboratory fixtures in the SAE J211 standard. The standardized coordinate system and polarities for data permits comparison of data from different crash test facilities.

There are many ways to influence the polarity of a data channel. NHTSA has required the polarity of any given manufacturers instrumentation be compatible with and recordable in a J211 channel. The channel by definition includes all the instrumentation from the transducer to the data acquisition system output. The channels therefore include the accelerometers mounted in the dummy connected to a data acquisition system using connectors, wiring, data acquisition software and hardware. The polarity of a data channel for any given dummy may therefore be affected by changing the manufacturer of the accelerometer, positive and negative pins from the accelerometer to the wiring in a connector, the polarity assigned in software, and by changing the way it is mounted in the dummy.

Since there are many ways to influence the polarity of a data channel it is appropriate to document the polarity of the assembled channel just before testing to assure the accelerometer is not exchanged with that of another manufacturer's, and that no changes are made to the way it is mounted in the dummy, the connector pin arrangement, and polarity assigned in software before testing.

When a test dummy is delivered for a test and connected to the data acquisition system the polarity of the internal accelerometers can be established using the following approach. The procedure requires the user to think of the data channel as a black box. The procedure requires manipulating the dummy head to determine the polarity of the black box with respect to the sign convention. If the polarity is wrong, than steps must be taken to correct it prior to submitting data to NHTSA, so that data is in accordance with the sign convention. However, it is recommended to correct and document the channel polarity at the test site so no further modification to the data are required. If difficulty is experienced in determining the polarity when these procedures are being properly followed it may indicate that the accelerometer has not been

mounted in accordance with the dummy instrumentation assembly drawings contained in the appropriate Nine Array Head with Redundant C.G. Accelerometers User's Manual.

### **SAE J211 Procedure :**

The body coordinate system used for reference is attached to the dummy and is x positive pointing forward, y positive pointing to the right, and z positive pointing down. For NHTSA tests the accelerometers referred to are those meeting NHTSA SA572-S4 specifications.

The SAE J1733 explains that for any dummy component oriented in its standard standing position blows to the back side, left side, and top will produce positive accelerations relative to its +x, +y, and +z directions, respectively. As an example to document the polarity of the dummy's head x axis accelerometer data channel in a plot similar to Figure 1, apply a blow to the back of the head with a rubber mallet and record the data channel output. The polarity of the Figure 1 dummy channel is positive and no changes are needed to conform to the sign convention. Similarly to document the polarity of the dummy's head y and z axis accelerometer data channels apply a blow to the left side, and top of the head with a rubber mallet (never apply the blow directly to an accelerometer mount) and record the data channel output as shown for the y axis in Figure 2.

Analysis of Figure 2 for the y axis shows that the polarity of the y axis accelerometer data channel in the dummy head in this example is negative. Change the polarity to be positive (perhaps the simplest way is to change the sign in the software) to agree with the sign convention and make a new plot to document the change. Following this approach it is possible to document the polarity of each accelerometer data channel in the dummy head.

### **Alternate Procedure :**

An alternate approach to determine the polarity of the accelerometers mounted in the dummy head uses the constant force of gravity as the input. This procedure will yield the same polarity as the previous procedure. Since the sign convention is fixed with respect to the dummy, this procedure can be conducted outside the test vehicle on the laboratory floor or table, but the dummy must be attached to the data acquisition system.

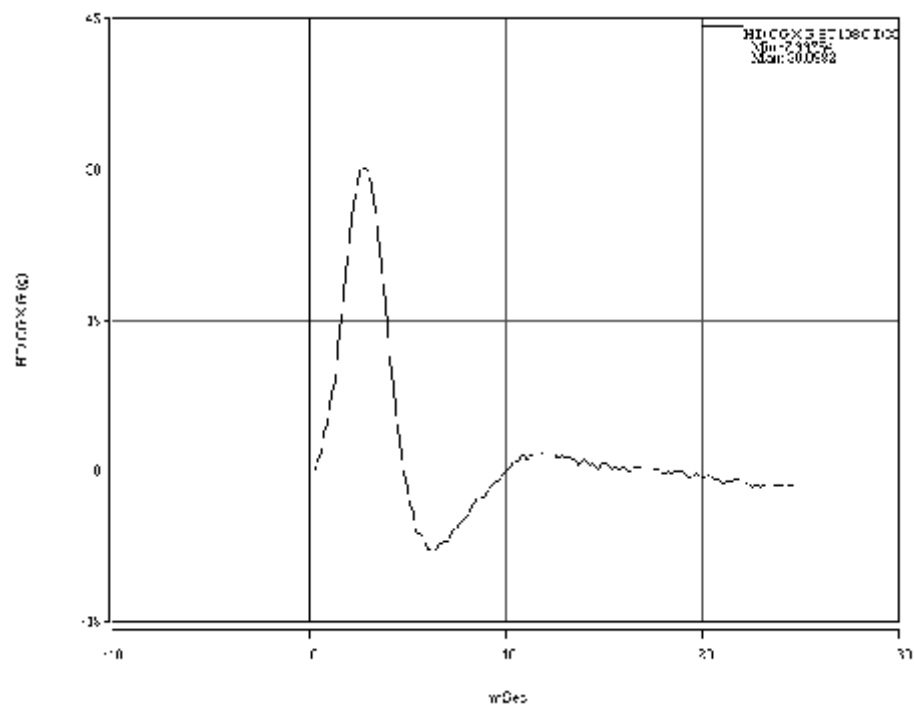


Figure 1 – Response of X Axis Accelerometer Data Channel from blow to rear of head showing desired positive polarity

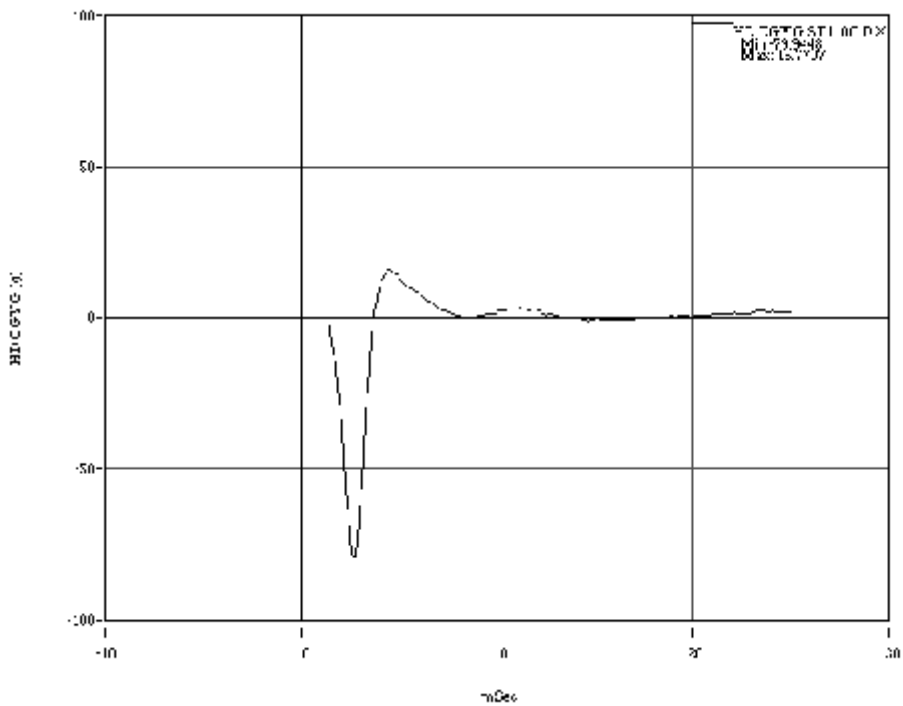


Figure 2 – Response of Y Axis Accelerometer Data Channel from blow to left side of head showing incorrect (negative ) polarity

The procedure for each channel requires placing the accelerometers to be checked perpendicular to the axis of gravity in two orientations each 180 degrees apart and recording the sign and value of the acceleration channel due to the earth's gravity for a short period of time. The SA572-S4 accelerometer is defined as perpendicular to the axis of gravity when the plane containing both mounting screw holes is perpendicular to the force of gravity. See Figure 3.

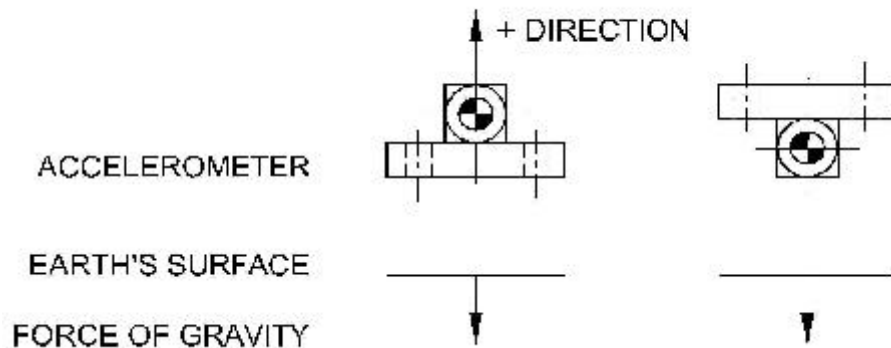


Figure 3 – SA572-S4 Accelerometer Perpendicular to the Force of Gravity in Two Orientations 180 Degrees Apart

When the SA572-S4 accelerometer is mounted in a plane perpendicular to the force of gravity the orientation of the dummy head having the most positive output for that accelerometer channel defines positive polarity when moved away from the earth center. The polarity must agree with the SAE J211 sign convention.

The data collected should be recorded in the Polarity Check Data Sheet respectively for the x, y, and z accelerometers. Samples of these are provided in this Document. As an example, refer to the Polarity Check Data Sheet for documenting the x axis polarity. To determine the polarity of the head x-accelerometer, lay the dummy face down (FD) and record the x-accelerometer's output in g's in the appropriate column. Now place the dummy face up (FU) and record the channel output in g's in the appropriate column. List the orientation of the most positive value in the next column, either FD or FU, paying attention to the sign from the data acquisition system (-1 is more positive than -2 g's). Next, compare the orientation of the most positive value with the J211 orientation for positive sign convention. If the dummy's orientation of the most positive value is consistent with that of the J211 sign convention, then the channel output will be in accordance with the sign convention. If, however, the dummy's orientation of the most positive value is different than that of the J211 sign convention, then the channel's output will have to be reversed by the data acquisition software in order to be in accordance with the sign convention. Place a check in the column titled "Negative Channels To Be Reversed In Data Acquisition System" for those channels that will require reversal by the data acquisition software.

The channel outputs for the x-axis accelerometers can be recorded simultaneously for each orientation. For example, when the dummy is turned face down, the channel outputs for the head can all be recorded at the same time. Then the dummy can be oriented face up and the corresponding channel outputs can be recorded again.

The procedure for the y-axis accelerometers is very similar to that used for the x-axis and can be accomplished on a floor or bench surface. In this instance, the dummy is placed on its side in two different orientations - one where the right shoulder is down (RSD) and one where the right shoulder is up (RSU). Once again, all of the channels can be recorded at one time. Then flip the dummy onto its other side and record the values again. At this point, the procedure is similar to that used for the x-axis channels. List the orientation of the most positive value and compare that with that J211 orientation for positive sign convention. Indicate those channels to be reversed if any.

For the z-axis turning the dummy over and standing it on its head is quite difficult for the larger adult dummies. Thus for the z-axis check it is recommended to secure the dummy in a chair, seat it upright and then rotate the dummy in the chair forward or backward about 60 degrees. The force on the accelerometer varies with the cosine of the angle it makes with respect to tangent to the earth's surface. With the dummy sitting upright (U) in the chair, record the z-axis accelerometer channel outputs in the appropriate column on the Polarity Check Data Sheet. Next, lean the dummy forward or backward approximately 60 degrees and record the z-axis accelerometer outputs in the column labeled "Lean Down." (Note that the symbol "D" for down has been associated with this orientation.) Again, follow the procedure outlined for the x-axis and y-axis accelerometers to complete the z-axis Polarity Check Data Sheet.

Polarity Check Data Sheet For X - Axis Accelerometers					
Dummy Type: _____		Serial No. _____		Date: _____	
Component	Channel Output ( g )		Orientation of Most Positive Value (FU or FD)	J211 Orientation for Positive Polarity	Negative Channels to be Reversed In Data Acquisition System
	Orientation				
	Face Down (FD)	Face Up (FU)			
Head C.G.				FU	
Head C.G. Redundant NAAH*				FU	
Head Top NAAH*				FU	
Head Left NAAH*				FU	

\* NAAH - Indicates Nine Accelerometer Array Head

Polarity Check Data Sheet For Y - Axis Accelerometers					
Dummy Type: _____		Serial No. _____		Date: _____	
Component	Channel Output ( g )		Orientation of Most Positive Value (RSU or RSD)	J211 Orientation for Positive Polarity	Negative Channels to be Reversed In Data Acquisition System
	Orientation				
	Right Shoulder Down (RSD)	Right Shoulder Up (RSU)			
Head C.G.				RSU	
Head C.G. Redundant NAAH*				RSU	
Head Top NAAH*				RSU	
Head Front NAAH*				RSU	

\* NAAH - Indicates Nine Accelerometer Array Head

Polarity Check Data Sheet For Z - Axis Accelerometers					
Dummy Type: _____		Serial No. _____		Date: _____	
Component	Channel Output ( g )		Orientation of Most Positive Value (U or D)	J211 Orientation for Positive Polarity	Negative Channels to be Reversed In Data Acquisition System
	Orientation				
	Upright (U)	Lean Down (D)			
Head C.G.				D	
Head C.G. Redundant NAAH*				D	
Head Left NAAH*				D	
Head Front NAAH*				D	

\* NAAH - Indicates Nine Accelerometer Array Head